GLACIATION OF SAN FRANCISCO MOUNTAIN, ARIZONA[1]

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During the summer of 1904 the slopes of San Francisco Mountain were examined with some care, and to the northeast of the main peaks records of ancient glaciation were found. The latitude of San Francisco Mountain is approximately 35° 21′, and the records of glaciation found here may possibly be those of the southernmost ice which existed in this country during the Pleistocene period.

San Francisco Mountain is in the north-central portion of Arizona, about ten miles north of the village of Flagstaff. It is of volcanic origin, having been built by numerous outpourings of lava and by explosions of fragmental material. The ancient crater of this mountain is bordered on the north, west, and south by a series of peaks (see Fig. 1) which are remnants of the once higher rim of the crater. These peaks rise to elevations of from 12,250 feet to 12,794 feet above sea-level, and nearly 7,000 feet above the general level of the plateau on which the mountain stands. To the east the rim of the crater is wanting, and the one stream which drains the central portion of the mountain flows through this opening or gap, and then, turning to the north, descends quickly to the alluvial deposits about the base of the mountain.

The general topographic relations, shown in Fig. 1, indicate that there is today a well-protected catchment area for rain and snow. The high walls on the south and southwest of the basin give the most favorable conditions, in this latitude for the preservation of snows. The floor of the crater varies in elevation from 10,000 to 11,000 feet, and is bordered by the bold, and at places, precipitous, slopes of the lofty peaks which surround it. The dimensions of the catchment basin are best seen in Fig. 1. The total possible area of

[1] The work reported in this article was done in company with a party of students from the University of Chicago, and the author is indebted to the members of the party for assistance in collecting data.

snow accumulation was about one and a half square miles, and the possible depth of snow and ice was somewhere near 2,000 feet.

Ascending the mountain from the east, the first morainic deposits appear at an elevation of about 9,250 feet and at a distance of about two miles from the head of the basin. At this point morainic ridges

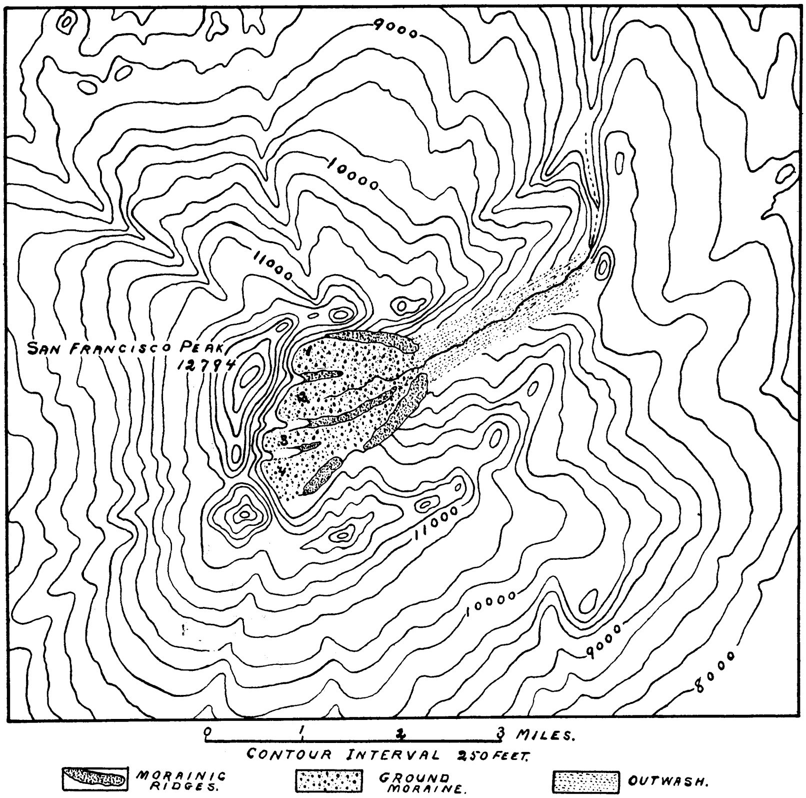

FIG. 1.—Topographic sketch of top of San Francisco Mountain, Arizona.

jut out into the valley from either side, but fail to cross the stream course and unite. This connection was probably complete at one time, but the material of the terminal moraine has been largely washed away.

Down-stream from the position of the terminal moraine there is a heavy alluvial deposit, made by torrential waters issuing from the end of the glacier. This outwash or valley train extends at least one

and a half miles down-stream, and perhaps much farther, but farther out it would be difficult to distinguish it from the preglacial and post-glacial alluvial deposits.

Up-stream from the position of the terminal moraine, the drift ridges, already mentioned, swing to appropriate positions for lateral moraines and continue to the lower margin of the basin, as shown in Fig. 1. The crests of these moraines are commonly but 40–50 feet above the valley bottom, but they increase in elevation to the eastward, until at their down-stream termini they are at least 100 feet high. The valley between the lateral moraines contains a drift-filling which at places is more than 50 feet deep, and which may perhaps be classed as ground moraine. In addition to the lateral and ground moraines, there are medial moraines projecting down-stream from the rock spurs which subdivide the basin.

The topography and topographic relations of these deposits of loose material are such that it would be extremely difficult, if indeed possible, to account for their formation under any other hypothesis than that of glaciation, but an examination of the material in these deposits furnishes conclusive corroborative evidence of glaciation. The material is entirely volcanic, but nevertheless has the characteristic physical and lithological heterogeneity of glacial drift. Bowlders up to 10 feet in diameter are found in the moraines, and in the exposed sections there is every gradation down to the very fine material in which the stones are imbedded. In all the exposures seen the drift was unstratified. Many of the larger stones and bowlders are sub-angular in form, with smooth and polished surfaces. In a region of undoubted glaciation, such forms and surfaces would have been accepted as positive evidence of ice-action, but in this region more conclusive evidence was looked for, and in the fresher exposures, especially in the débris from a 30-foot excavation in the bottom of the valley, beautifully striated stones were found.

The basin is not cirque-like in form, and probably it was not greatly modified by the ice. It is subdivided at its head by projecting rock spurs into four minor upper basins (1, 2, 3, 4, Fig. 1). Basins 1 and 2 have floors which are broader than would be expected if developed by stream-erosion alone. On the floor of the basin numbered 1, a surface of bed-rock is exposed which has been polished and

grooved. The stoss sides of all minor prominences on this rock are characteristically worn. On the floor of the basin numbered 2, there are irregular hillocks or mounds which were formed by the ice, and among them were formerly small ponds or marshes. The minor basins numbered 3 and 4 show little modification due to ice, but it may be that the extensive talus slopes obscure the former flat bottoms of these basins. No proof of more than one epoch of glaciation was found.

Since the melting of the ice, the amount of erosion accomplished has not been great. Much of the talus material about the rim of the crater is presumably of postglacial age, but the washing away of the terminal moraine along the main stream is the most conspicuous task that has been done. The surface-weathering of the glacial material is so slight as to be insignificant.

In comparison with the records of ice-action in higher latitudes in this country, the records on San Francisco Mountain are meager. They indicate appropriately weaker glaciation in this lower latitude.